NOTE ON IRRIGATION

IN THE

JODHPUR STATE.

1905.

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NOTE ON IRRIGATION IN THE JODHPUR STATE, 1905.

The following remarks were made by Rao Bahadur Pundit Sukhdeo Pershad, C.I.E., on the above Report, and are, therefore, now added for information and record :—

Remarks by Rao Bahadur Pundit Sukhdeo Pershad, C.I.E., on Colonel Sir S. Jacob's Note (1903) on Irrigation, Jodhpur State.

Paragraph 1.—No remarks.

Paragraph 2.—Country to the north-west and south-west of the city is sandy.

Paragraph 3.—No remarks.

Paragraph 4.—Mostly by camels and the seed planted not so deep as is done by ploughs worked by bullocks. All grain is taken and stalks are only allowed to stand as fodder for cattle. They do store the excess grain.

Paragraph 5.—The Luni overflows its bed in Mallani and Sanchore. Its water while the river is flowing in full force is sweet, and when flowing in very small quantity it is brine.

Melons in great quantity, and singhari only here and there are grown in the bed of the river.

Paragraphs 7, 8, 9 and *10.*—No remarks.

Paragraph 11.—"Guya" in place of "Gunga."

Paragraph 12.—No remarks.

Paragraph 13.—The number of villages including Mallani, which is now a part and parcel of Marwar, is 4,241, of which 606 are wholly Khalsa and 97 in part.

Paragraph 14.—No remarks.

Paragraph 15.—Some of them do belong to persons of importance, such as Rao Raja Raghnath Singh. It is only when the "Dil-gaon," *i.e.*, the village after which the Thikana is known, is concerned that the question of exchanging the village becomes difficult, else, as a rule, the Durbar has always a right to grant the village of equal rental to any Thikana for their village which might be made Khalsa for irrigational purposes, and this right is loyally admitted by all concerned.

Paragraph 16.—The Thakur of Bankli was not a minor, but the real cause was that he had influence with His Highness, and so the question of exchange was not taken up.

Paragraph 17.—No remarks.

Paragraph 18.—No remarks.

Paragraph 19.—In some cases owing to the weakness of the administration, such as in Maharaj Zalim Singh's village, Lamba, no charge is made for irrigation, but as a rule, the Durbar collects higher rates of rent on irrigated areas by adding Rs. 2-8 as watering charge per bigha to the soil rates. In Sewaj land we take Rs. 2 per bigha as saturation fee in addition to soil rates. When we take our share under the "Batayi" system we get one maund per bigha (*i.e.*, one-third of the average Sewaj produce) on the Sewaj land; and we take one-fourth the produce of the irrigated crop which is equal to a maund and a-quarter, as the produce in an irrigated bigha is far more than in a Sewaj bigha.

Paragraph 20.—The amounts noted are incorrect. They should be:—

	Rs.
1889-90	1,29,506
1890-91	1,60,321
1891-92	1,80,483
1892-93	95,272
1893-94	1,69,348
1894-95	2,04,822
1895-96	66,024
1896-97	26,020
1897-98	4,249
1898-99	6,901
1899-00	6,16,718
1900-01	4,72,126
1901-02	2,65,347
1902-03	1,26,626

Note.—The sums overleaf include Rs. 1,17,814 spent on Chopasni Bund.

Paragraph 21.—The cost of irrigating a bigha ranges from 7 to 9 annas according to the depth of water from the surface.

There are 5 waterings in the sweet wells, and 7 in saline and deep wells generally.

One pair can irrigate from 2 to 3 bighas according to the depth of the water from the surface.

Paragraph 22.—The average produce of the irrigated crop is about 5 maunds per bigha, and about one maund in the unirrigated (Bārāni). The area lying within the main bed of the tanks yields nearly 6 maunds per bigha, and ordinary Sewaj 3 maunds a bigha.

Paragraph 23.—Different water-lifts are used for different depths, *viz*:—

Odia—A water-bucket made of bamboos, with leather strip attached to both sides when the water is about 4 feet deep.

Dhekli—A horizontal wooden beam with a heavy weight tied on one hand, and a small earthen bucket hanging by a string at the other, is balanced or hinged on to a vertical post. It is worked when the depth is about 9 feet.

Pag-pati—Is a miniature Persian wheel, and as its name implies is worked by feet, when the depth is about 15 feet.

Sundia—A leather bag with a proboscis, and is used for wells where water level is higher. It is worked when the depth is up to 35 feet.

Arath—Persian wheel. It is used when the depth is up to 80 feet.

Jhelwa—A leather bag. It is used when the depth is up to 130 feet.

Paragraph 24.—The depressions at Didwana and Pachpadra differ in as much as the former is a regular lake, where the water remains throughout the year, and it is utilised in manufacturing salt; whereas at Pachpadra the rain water is received in deep pits situated apart, and nowhere is water visible on the surface.

There are marshes caused by inundation.

Paragraph 25.—The assessment of land varies from one-third total produce on Sewaj land (including soil and water rate) to one-fourth on ordinary irrigated land, or its equivalent in cash.

On unirrigated land (Bārāni) the assessment varies from half total produce in a few places, where the soil is very rich, to one-fourteenth total produce where the soil is poor, or the equivalent of the above in cash.

Paragraph 26.—No remarks.

Paragraph 27.—We have already applied for the service of one.

Paragraph 28.—*Vide supra.*

Paragraph 29.—No remarks.

Paragraph 30.—Names require correction. They are:—

"Surpura" for 'Soopura.'
"Katholi" for 'Ratholi.'
"Miniari" for 'Maivari.'
"Banbholai" for 'Bankolai.'
"Sovania" for 'Sormia.'
"Magar Talao" for 'Majan Talao.'
"Jor Band" for 'Gorband.'

Paragraphs 31, 32, and *33.*—No remarks.

Paragraph 34.—It is "Pundlota" lake and not "Digana."

Paragraph 35.—No remarks.

Paragraph 36.—At a cost of Rs. 2,01,899.

Paragraphs 37 and *38.*—No remarks.

Paragraph 39.—There is no difficulty in exchanging villages except the "Dilgaons."

Paragraphs 40 and *41.*—No remarks.

Paragraph 42.—In the tabular statement the names of the villages should be Bhavi, Pichyak and Malkosni.

Paragraph 43.—Amount spent during Famine has not been shown, which on the Dholera work came up to Rs. 4,23,541.

The same may be said of Kairla on which Rs. 61,870 were spent in the last Famine, *in addition* to the figures given by Sir S. Jacob, which latter only were charged to Public Works Department.

Paragraphs 44 and *45.*—No remarks.

Paragraph 46.—The Durbar is alive to, and admits the force of all suggestions noted in the paragraph with the exception of No. 12, for which reference has already been made under Paragraph 15.

2. The Jodhpur Durbar having asked my opinion regarding the water supply for the City of Jodhpur I visited Jodhpur on the 17th February 1905. On the 18th I inspected the site on Paota hill, proposed for a service Reservoir, and the Storage Reservoir at Balsamand, about 6 miles north of the City, and some small springs which issue from the natural rock at Mandor, about 2 miles further north in the same range of sandstone hills. On the 19th February I inspected some of the wells on the plain below Mandor, from which water was pumped by Mr. Home, when there was a great scarcity of water in the year of Famine 1899, and I also visited Nemba, about 1 mile further north of Mandor in the same range of hills, where another small spring issues out of the rocks.

On the 20th February I visited the Storage Reservoirs at Chopasni, about 7 miles, and Kylana about 5 miles west of the City.

Mr. de Closets, the State Engineer, came with me and showed me all of the above places; we had no time to go elsewhere.

3. There is a nullah which rises in some hills about 30 miles north-east from Jodhpur in the direction of Barlu; and a few miles after it leaves these hills loses itself in the plain below. Whether it will be possible to dam this up, somewhere near Gonamand, where it issues from the hills; or whether, if bunded up, the water will be retained; or whether levels of the water, if successfully stored here, will admit of the water being taken to the city, are all points which need to be investigated. There appears to be a drainage area here of about 70 square miles, and if only one inch of rain was stored here it would represent about 150 millions c.ft. But this, like all Storage Projects in these parts, depends upon the rainfall, which is very uncertain.

In any case it would be a costly project and without further data it is impossible to say more.

At the same time I would suggest levels being taken and the Project investigated.

If the water now goes to waste and can be stored at a reasonable cost, if nothing else can be done, it is possible it might be used for Irrigation, and would certainly benefit the country.

4. To show how matters now stand it will be advisable to give a short history of the subject:—

In the Administration Report for 1892-93, para. 29, it is stated "The water of the Balsamand is used for irrigating lucern grass for the Maharaja's stables, for His Highness' private gardens, for the Cavalry Lines, the Jail and the Railway Station. It is only used for the City in cases of urgency when all the tanks in the latter have dried up. The Durbar being anxious to procure a proper supply for the City, a tank is being made at Chopasni, a village 4 miles to the west of the City. There is a Catchment area of about 14 square miles which should give an ample supply. The estimate made some years ago is Rs. 1,01,607, but borings taken at the time the estimate was made are found to have shown rock

on a bed of boulders, through which the foundations will have to pass, and which will cause the old estimate to be considerably exceeded. A new estimate is being prepared, and in the meantime the Durbar has ordered the work to be proceeded with, to enable the foundation to be got in, if possible, before the rains."

The expenditure to date has been Rs. 2,118 on Survey and excavation of founds.

In the Administration Report for 1895-96, paras. 33 and 34, it is stated "This tank is now complete." It, however, received only 7 feet of water owing to failure of the rains on that side of the city.

The tank has cost Rs. 1,53,405, which was spent as follows :—

Excavation of foundation, including pumping, 2,468,000 c.ft.			Rs. 23,364
Earthwork in bunds, 4,411,000 c.ft. ...			„ 22,770
Rock-cutting, 67,500 c.ft.			„ 21,709
Masonry in core-walls, 440,000 c.ft. ...			„ 67,667
Pitching, 1,45,100 c.ft.			„ 3,199
Sluice			„ 4,614
Canal to divert water into tanks :—			
Rock-cutting, 219,700 c.ft. ...	...Rs. 4,210		
Earthwork, 283,000	... „ 1,177		
Masonry, 91,600 c.ft.	... „ 14,169		
Concrete, 11,200 c ft.	... „ 1,340		
			20,896
Overflow :—			
Earthwork, 223,000 c.ft. ...	...Rs. 1,216		
Rock-cutting, 27,500 c ft. ...	... „ 857		
			2,073
Additional Bund for Leakage :—			
Excavation, 135,000 c.ft. ..	...Rs. 2,341		
Masonry, 15,500 c.ft.	... „ 3,252		
			5,573
Contingencies	...		540
	Total ..	Rs.	1,53,405

In the meantime, the Kylana Storage Reservoir made by order of Maharaj Sir Pertap Singh, had filled with water, and Mr. Home, the Manager of the Jodhpur-Bikaner Railway, and State Engineer, had made a system of masonry catch-water drains, contoured round nearly all the rocky hills near the city, and by these water was conveyed from both reservoirs, Balsamand and Kylana, to the Masonry Kunds in the city, and supplied the wants of the people.

In his Administration Report for 1896-97, he writes as follows:— Para. 13.

"The Durbar has decided to supply the town of Jodhpur with clean water, delivered in pipes, and an estimate has been submitted.

The source of supply will be the Kylana and Balsamand Tanks, which are at present connected with the town by canals 6 by 3 miles long. The total amount of water available is about 130 millions cubic feet, and the maximum amount required daily is estimated at one million gallons.

It is not likely, however, that the consumption will reach this figure for some years, as the majority of the population has a prejudice against using water that they do not draw from wells or tanks.

The above-mentioned canals will lead the water to the foot of Paota hill, where it will be filtered and then pumped up a height of 170 ft. to the top of Paota hill, to a service Reservoir, from where it will be delivered in pipes to the city.

The abstract of the estimate is as follows :—

	Rs.
Prolongation of the Kylana and Balsamand Canals of Paota	32,262
Filters	21,634
Engine-house	10,000
Engine and Boiler	70,000
Service Reservoir	13,690
Pipes, Sluice Valves, etc.	2,18,819
Contingencies	18,320
Total ...	3,84,725

The Durbar proposes to spread the laying of the pipes over a term of years."

In his Administration Report for *1899-1900*, Mr. Home writes as follows :—

"*Paragraph 29*—Water supply of Jodhpur City.—The usual supply of the city is from tanks that are filled up during the rains. There having been no rains this year, the tanks were all empty by the month of August, and the people were dependent on a few and insufficient number of wells. An arrangement is now working by which 160,000 gallons of excellent water are run into the city daily, which sufficiently supplements the supply from local wells. This water is supplied from a series of sixteen wells, near Mandore, 5 miles from Jodhpur. It is drawn by bullock-power from the wells and run to a central masonry tank, whence it is pumped up by a small Worthington pump and delivered by pipes to the Gulab Sagar Canal, nearly a mile off, through which it runs to the city.

The water thus supplied is clear and sweet, but the inhabitants of Jodhpur complain of it, as it is a mixture from several wells; which for some occult reasons is supposed to be objectionable."

Relative levels of Balsamand, Kylana and Chopasni Tank Sluices :—

Balsamand Sluice level	140·00
Kylana	138·00
Chopasni	79·00

5. Mr. de Closets, the State Engineer, came to Jodhpur in August 1904. At the request of the Durbar he took up the subject, and now gives me the following Note :—

Note on Balsamand and Kylana.

Situation of Balsamand, 3 miles due north of Jodhpur City.
Catchment area, 5 square miles (free).
Catchment intercepted by ducts to afford extra supply, 5 sq. miles.
Capacity at 38 feet depth (by Mr. Home) = 54 millions c.ft.
At rate area $= \frac{54}{38} = 1{\cdot}42$ millions sq. ft. (average).
And thus at 40 ft. depth, capacity $= 1{\cdot}42 - 40\frac{7}{8}$ = say 57 m.c.ft.

Observations of water level :—

Tank filled in 1903, and level of water on 13th August 1904, or say one year after was 25 ft. Difference, 15 ft. in 360 days = $\frac{1}{2}$-inch a day.

Water level on 23-8-04 = 24′-0½″ difference = 6″ in 10 days = ·60″ a day.
„ „ 5-9-04 = 23′-10″ „ = 8″ „ 13 „ = ·61″ „
„ „ 16-9-04 = 23′-5 ″ „ = 5″ „ 11 „ = ·45″ „

Note.—It rained on the 15th September 1904, and some water must have come in.

Water level on 26-9-04 = 22′-10″ difference = 7″ in 10 days = ·70″ a day.
„ „ 5-10-04 = 22′-5″ „ = 5″ „ 9 „ = ·55″ „
„ „ 29-10-04 = 21′-5″ „ = 1′0″ in 24 „ = ·50″ „
„ „ 16-11-04 = 20′-8″ „ = 9″ „ 18 „ = ·50″ „
„ „ 20-12-04 = 19′-3″ „ = 1′5″ „ 34 „ = ·50″ „
„ „ 13- 2-05 = 17′-3″ „ = 2′0″ „ 56 „ = ·43″ „

The average decrease per day, as above noted, is ·53″.

In the hot months the decrease may be taken at ·73″ a day.

The above is due to evaporation, absorption, percolation, and to water served daily.

The quantity served daily is about 10,000 c. ft.

The maximum evaporation, absorption, and percolation only in the hot months may be taken at ·60″ a day.

The minimum may be taken at in cold months at ·18″, average ·39″ a day.

Decrease due to water served, say ·55″ — ·40″ = ·15″ per day.

Then $\frac{1}{7}$-inch or $\frac{1}{84}$-foot over × = 10,000 or 10,000 × 84 = 840,000 sq. ft., the average area 840,000 × 40 = 33·6 millions c. ft. capacity.

The maximum decrease at ·73″ and minimum at ·43″ gives an average of ·58″ per day for all causes.

In 365 days this means 211·70 inches, and in 2 years = 423·4 inches = 35 feet and 3 inches.

It is proposed to make the Reservoir 2 ft. deeper, or = 42 ft. depth,

NOTE.—Balsamand ran dry in 1900.

which will give it, say, 60 millions c. ft. capacity. Even then the supply available after two years will only be say, 7 ft.

The tank can certainly not supply more than 10,000 c. ft. a day, or what is at present served.

The railway will be supplied by Kylana, and as the supply they take now is 5,000 c.ft. a day, out of the 10,000 c.ft. served, only so much as 5,000 c. ft. a day will be available for the city supply from Balsamand.

Difference of levels between Kaga Reservoir and Balsamand Sluice about 14 ft.

Difference of levels between Kaga Reservoir and Kylana Sluice about 13·50 ft.

Kylana Reservoir is about 50 per cent. more in capacity than Balsamand, and other conditions taken as same as Balsamand, could, therefore, supply 15,000 c. ft. a day, of which 5,000 c. ft. will be taken by the railway, leaving thus 10,000 c.ft.

Of these 10,000 c. ft. fully 2,000 c. ft. a day may be reckoned as the average required for filling Ratanada from time to time, leaving 8,000 c.ft. a day available for the city.

Total available for the city = 5,000 from Balsamand and 8,000 from Kylana = 13,000 c. ft. daily for two years following a good one.

6. This shows how the matter now stands.

The following points deserve consideration :—

(1) The population of the City is said to be 70,000; allowing 10 gallons a head, the quantity required daily will be 700,000 gallons ... ... 112,000 c.ft.

The Railway now take daily	5,000	
Total required daily ...	117,000	
„ „ yearly ...	42,705,000	
		m.c.ft.
The total capacity of Balsamand is ...	57	
„ „ „ Kylana	76	
If Balsamand is raised 2 ft., it will add	3	
And by slightly raising the dams of the small tanks between the city and Balsamand, and using their water that is now allowed to flow into Gulab Sagar and Fatch Sagar, say, about	12	
Making the total quantity about ...	148	

The loss by evaporation, absorption, and percolation in these sand-stone hills has been shown by Mr. de Closets to be an average of ·4 of an inch per diem ; in the hot months it has been as much as ·7. This would represent a depth of about 12 ft. from each tank ; probably about one-third of their capacity, or say 45 m.c.ft. This agrees with Mr. Home's statement that the joint supply would be probably 100 m.c.ft. This is on the supposition that both Reservoirs fill.

(2) It must be remembered that these tanks depend entirely upon the rainfall, which is extremely precarious. In 1899 they were both dry.

(3) No scheme can be considered safe which does not have a large reserve to tide over a bad year.

(4) Chopasni Reservoir is not to be depended upon; even when it filled, the water all disappeared in a few months, and although it held 11 ft. of water last September, now (February) there is only 1½ ft.; 10 ft. has disappeared. It may, perhaps, improve in time, and if it filled, water might be pumped up and passed into the masonry duct to supplement the Kylana supply; but it would have to be raised about 75 ft., and as the supply is so uncertain, it is not safe to place any dependence on it.

(5) It is proposed to place the Service Reservoir on Paota hill, which is 70 to 100 ft. above the greater part of the city. The Railway and a small part of the city are now supplied by gravity. It is not stated whether these are to be included in the pumping scheme, but it manifestly is not necessary to raise water to the height proposed for those places which can be served by gravity. These parts might therefore be excluded.

(6) If it is decided to have a pumping scheme, it is a question whether it would not be advisable to divide the city into 2 or more zones, A, B, and C, each about 20 or 30 ft. above each other, with a Service Reservoir for each. It would only be necessary then to pump to the highest point the quantity actually required for A; so on for B; and so on for C. The same set of pumping engines, of course, would supply all as required.

(7) In the water famine of 1899, water was supplied from wells on the plain east of Mandor, five miles from the city; the water was drawn by bullocks from 16 existing wells, and run to a central masonry tank, and pumped up by a small Worthington pump, and 160,000 gallons were delivered by pipes to the Gulab Sagar Canal, about a mile distant, and so passed to the city.

Although the quantity is small, yet it was sufficient to supply the immediate want of the people.

(8) The fact that this water was got from wells here, and that small springs now issue from the Mandor range of sandstone hills, indicate that there is water below the ground in this direction. The quantity we saw issuing from the rocky hills was very little, and in the wells we inspected on the plain it was about 85 ft. below the surface. It is difficult to say what quantity exists, as Zamindars only make their wells deep enough to supply their need.

(9) The water is said to be clear and sweet, but the people are said to object to any water which is a mixture from several wells, probably for caste reasons.

(10) It might perhaps be possible to store some of the water which now finds its way into Bhagat Sagar, and dries up there, by making small storage tanks in hollow places in the hills, and leading it afterwards by a masonry duct to the existing Channel; but, if such places exist, it would always be uncertain if these would fill, and it would certainly cost a considerable sum: to incur this outlay on an uncertainty is not, I think, advisable.

(11) It is taken for granted that all the water which falls in the rains on the rocky hills in the vicinity of the town has been intercepted and stored. If not, this should be done.

7. Taking all these facts into consideration, it appears to me that before attempting any pumping scheme for the city, the first thing is to insure a good supply of water. If no natural source exists of adding to the present supply, or can be provided at a reasonable cost, then I would suggest:—

(1) The level of the water in all the wells on the plain below Mandor should be ascertained and reduced to one datum in order to see the general level of the sub-soil water; if it is found to fall uniformly in one direction, the probability is that it is in this direction it is passing away.

(2) At a low place on this plain, a good Well be made, and the capacity of the supply be tested by a good steam pump. If satisfactory, a pipe could be laid from this well to the nearest point on the Gulab Sagar masonry duct to the City (as was done by Mr. Home in 1899), and whenever the need arose the water could be pumped up at short notice.

(3) If one well was found not to yield a sufficient quantity of water, then a boring might be made to test whether other springs exist, which are not tapped by existing wells.

(4) Or other wells might be constructed and connected with the one on which the pump is fixed until the required amount of water was obtained.

(5) There need be no expense incurred in pumping, until the need arose, but everything would be ready.

(6) In the meantime the wells could be used for Irrigation, so that in those years in which they were not required for the city the water could be used, and some return be received for the expense of making them. It would not be money thrown away.

(7) A supply of 10 gallons a head might not be obtained; still sufficient might be given as would afford a good drinking supply, and it would always be ready.

8. The Jodhpur Durbar having requested my views on the Estimate of the Bankli Bund, I visited the work with Mr. de Closets, the State Engineer, on the 21st February 1905. This work is alluded to by Mr. Home in his Report as follows:—

"Bankli Bund, across the Chanode River.—This Project was prepared in 1899 as a famine work. Construction was started that year, and about half of the earthwork was thrown up. At the beginning of the rains of 1900 the work was abandoned, as neither labour nor funds were available. The estimated cost is Rs. 2,38,000, the catchment area 400 square miles, the capacity of the tank 1,300 million c.ft., the storage 5,500 c.ft. per rupee of cost, which is exceptionally good."

9. Mr. de Closets, the State Engineer, has given me a Note he has just prepared, of which the following is a copy :—

Note on Edward Samand—Bankli Bund.

"This Reservoir will be situated some 7 miles to the north of Bhadrajun Town, a mile south of Bankli village, or in east longitude 72°-57′ and north latitude 25°-43′ in the Jagir of the Bhadrajun Thakur.

The villages in its bed, and those affected by its channels being his, with a few exceptions, the following are details of the work :—

Drainage area	...	450 sqr. miles.	
Area of waterspread when full	...	6 „ „	
Capacity	...	970·82 m. c.ft.	
Height of Bund (maximum) ...	..	37 feet.	
Greatest depth	...	17 „	
Cost during last Famine ...	Rs.	2,28,772	
Now estimated to complete ...	„	1,83,625	Rs. 4,12,397
Cost of Storage per rupee ...	...	2,351 c.ft.	
Length of Bund...	...	2 miles 7½ furlongs	
Slopes of Bund	...	4 and 3 to 1	
Top of Bund	...	R. L. 137	
Top of Pitching	..	R. L. 131	
M. W. L.	...	13·00	
F. T. L.	...	127	
Sill of Sluices	...	115 and 110 respectively.	

Bye-washes at right flank, and on ridge to the east ; combined 1,000 feet long.

The bund is to be raised with sandy soil, with a masonry core-wall 1,300 feet long, across the Sukri River, founded on a hard stratum of lime kunker, some 4 to 10 feet below river bed.

There will be two sluices with tower heads, and two sets of screw-geared cast-iron shutters, 2 ft. diameter in each.

Two canals, one on the right bank and one on the left, will irrigate some 6,472 acres of land at 150,000 c.ft. per acre ; more than double this area is available.

This work was started in 1899, and continued as Famine Relief in 1900, the total expenditure on it being Rs. 2,28,772 to end of 1900-1901; only some 11,665,000 cubic feet of earthwork being turned out, which means nearly 51 c.ft. per rupee, or Rs. 20 per 1,000 c.ft.

The work has now been resumed towards completion on 1st October 1904 to provide Famine Relief to the south-western Perganahs of the State.

10. The Estimate for completion of the Bund, including, pitching is ... ... Rs. 88,650
For the core-walls ... ... ,, 76,000
,, Sluices ... ... ,, 10,275
Contingencies .. .. ,, 8,700

(*See Appendix A*) ... Total Rs. 1,83,625

(1) It is estimated that if all goes well and the Famine is not more severe than at present, the work will cost some 5 or 10 per cent. less than the estimate.

(2) The whole work will not be finished this season, but the founds of the core-wall will be laid, and some 6 to 7 feet masonry built over the river bed, and the whole earthwork on sides of the river finished.

(3) An estimate, dated 22nd November 1904, was submitted by Mr. de Closets for this work, amounting to Rs. 1,83,625, copy of which is attached (Appendix A.)

11. The opinion of Major Tilley, R.E., Executive Engineer at Mount Abu, was asked on this estimate on the 7th December 1904. "Assuming for local reasons it has been decided that it is impossible to put in the usual puddle-core, and that it must be a masonry one," he submitted his opinion in the following Note :—

(1) For the portion of the core which is one foot below the ground level, I recommend the use of concrete, and not masonry. It has two very strong recommendations.

First—It is considerably cheaper.

Second—If carefully mixed and laid, it forms a solid block, and is more impervious to action of water than masonry.

(2) The concrete foundation would, of course, be arranged in steps following the natural slope of the ground on either sides. (I am now speaking of the longitudinal section of the Dam.) If this is done it should decrease the Estimate by a considerable amount.

(3) The rate in the estimate, *viz.*, Rs. 16 for concrete, appears to me to be very high. The rate here at Abu for concrete made of 100 parts ballast to 40 of mortar (the mortar being described as follows) is Rs. 14, and at Ajmer the rate is Rs. 10.

(4) I should strongly recommend the core masonry above the concrete base to be constructed of random rubble throughout; the stone being carefully selected and laid.

(5) The advantage of this form of masonry for this particular purpose is obvious, as there are no through joints through which, owing to any slight defect in the masonry, water may be able to find its way, as is more likely to be the case in masonry where the stones are laid in regular course.

(6) For the best random rubble our rate in Abu is Rs. 19, and it could probably be done cheaper at Jodhpur.

(7) If, as I infer, the line used is kunkar line, I do not understand why it should be non-hydraulic. Assuming however, that it is only slightly hydraulic, I certainly think that *surki* should be used in the preparation of the mortar.

(8) For ordinary building purposes here, in Abu, where our lime is burnt from Abu Road lime stone, and is pure fat lime, our mortar is made in the following preparations :—

1. Lime.
1. Fine nullah sand.
1. Surki.

This forms an excellent mortar which sets somewhat slowly, but eventually becomes very hard.

(9) In the construction of the new Agency Offices, which will be a large building, in places four stories high, I propose to use mortar made as follows :—

1. Lime.
3. Fine clean washed sand.
1¼. Surki.

(10) The danger in using lime and surki only for mortar is that when drying the mortar is apt to shrink and develop fine hair cracks in the joints.

(11) It is difficult to express an opinion without any samples to judge from, but I should think that a mortar similar to that used here, *viz.*, equal parts of kunkar lime, fine clean washed river sand, fine ground surki would prove satisfactory.

(12) If Mr. Home succeeded in constructing coursed rubble masonry with a mortar of kunkar lime and river sand for Rs. 14, I should think that random rubble masonry, with mortar, made in the proportions I propose will cost about Rs. 17 per cent. c.ft. This would effect a saving of Rs. 19,500 on the core masonry.

(13) I also think that this class of masonry should be carried up to a height of 2 feet above weir level.

Copy of D. O. No. D-4-846, dated 11th December 1904, from the State Engineer, Raj Marwar, Jodhpur, to the Mehekma Khas, Raj Marwar, Jodhpur.

12. "In reply to your No. 3237, dated yesterday, enclosing Note on Bankli Bund by Major Tilley, I write to say that the rates in my estimate for the same are based on what has been paid before.

For Dholera Bund (Sardar Samand) the rate paid by Captain Bremner was Rs. 20 per cent. c. ft. for masonry, of mortar made of $\frac{1}{2}$ lime and $\frac{1}{4}$ surkhi. I have allowed the same rate for mortar of 1 lime and $1\frac{1}{2}$ surki, as well as 1 lime, 1 sand and 1 surki.

Mr. Home, in his estimate for Dholera, allows Rs. 25 per cent. c.ft. for masonry with surki mortar.

Concrete without surki has been paid for before this at Rs. 14 per 200 c.ft. in Jodhpur. My rate with mortar of 1 lime and $1\frac{1}{2}$ surki is Rs. 16 per 200 c.ft.

I do not pretend for a moment to know the rates of the place as yet, but guide myself by precedents.

The mixture of 1 lime, 1 sand and 1 surki does not set under water after it has been allowed to set for 36 hours in the open, but that of 1 lime and $1\frac{1}{2}$ surki does. That is why I have adopted it, but I quite agree with Major Tilley that some sand must be mixed with it.

The coursed rubble masonry of the core-wall will only be for the face work, and random rubble for the hearting; the rate being an average one and the term "coursed rubble" adopted so as to get as good random rubble as possible, Contractors being apt to take advantage of random rubble, if that is stipulated.

I also concur with Major Tilley that concrete should be used in preference to masonry where we can do so. I have allowed concrete for filling trench in foundation in soft rock and such, but above where sand has to be cleared to a much wider dimension than the trench, as it will not otherwise be possible without special appliances to put in concrete, I have allowed masonry for core-wall."

13. After reading the above and inspecting the Plans and Site, I venture to make the following remarks:—

(1) As regards the Plans, the top width of the Dam is shown 20 ft. thick—

R. L.	..	...	137
Maximum Flood L.		...	130
H. W. L.	...	...	127

As the inner slope is 4 to 1, and the outer slope 3 to 1, it makes the bund 90 ft. thick at H. W. L. This is unnecessarily thick, but as most of the earthwork is done, it is not possible now to make much saving on this. The top width need not be more than 15 ft. thick anywhere.

If any saving can be made by reducing the top width to 15 ft. on the part remaining to be done, it might be safely done.

Reducing the top width has this advantage also, that there is not so much surface water to dispose of when it rains. The effect is seen by the way the bund surface has been already cut up and the gutters made in the slopes, both outside and inside. To prevent this, small ridges of earth should be made at each side, and across the top at short intervals, to divide the top surface into small compartments, and prevent the rain water accumulating anywhere. It is only when it accumulates that it does any damage.

(2) Where there is a core-wall the earthwork need not be put up to the same level, but might be kept 2 ft. lower on each side, but this will not save much here, as the core-wall is only 1,300 ft. long.

(3) In the culvert for the outlet Sluice—it is a good Plan to put a masonry core-wall, projecting 15 ft. on each side, and also 6 ft. above the top of the culvert arch, to prevent any creep of water between the masonry and the earth.

(4) Stone pitching has been taken everywhere to a height of 1 ft. above H. W. L. on the inner slope. Estimated cost Rs. 18,250. I think it may be possible to effect a saving here by only putting pitching, where the water will be more than 5 ft. deep. If found to be necessary elsewhere, it can be put afterwards. Wherever pitching is adopted, I would suggest a 3 inches layer of small broken stone or kunkar underneath, to prevent guttering of the slope below the pitching. It is possible the inner slope will be cut up by wind and water, when the tank fills, and repairs be necessary, or the slope to be made more than 4 to 1, where there is no pitching.

(5) As regards the escape—it is not advisable to have any escape, I think, in the line of the bund. The soil here is not to be trusted, and any flow of water here might do harm. The long escape proposed at the east side over the natural surface appears to be all that is required ; the ground is hard and the slope very gradual, and any surplus water ought to pass off here without damage.

(6) The soil at the north-east end of the land is bad : and from the way the rain water has cut it up and broken through the slopes it would appear that there must have been clods. The portion of the bund from chain 12,000 ft. to 14,000 will require to be carefully made up, and watched in the rains. Fortunately there will only be about 5 ft. of water here.

(7) Instead of putting the H.L. Sluice where it would be necessary now to cut through the bund, it might apparently be put in the gap at 10,200, where no earthwork has yet been done.

(8) As regards the rates for masonry and concrete. From an examination of the details of the rates and the distance of the quarries, the rates which have been allowed to the Contractors appear to me to be very liberal. I understand the Contractors have been allowed Rs. 17 for masonry, and Rs. 14 for concrete per 100 cubic feet; I think masonry and concrete can be done well here for Rs. 15, and Rs. 12, but it must be remembered that Contractors will not take up work unless they can realise a good profit, especially in an out-of-the-way place like this, and whether any Contractor would take less than these rates is very doubtful.

(9) The original estimate can therefore be reduced by—

(*a*) Revised section in earthwork.

(*b*) Omitting stone pitching where the water is less than 5 feet deep.

(*c*) Revised rates in masonry and concrete.

Mr. de Closets has prepared a Revised Estimate accordingly, adopting the rates allowed to the Contractors, *viz.*, Rs. 17 for masonry, and Rs. 14 for concrete per 100 cubic feet; this shows a reduction of (Rs. 1,83,625,—1,53,534) Rs. 30,091. (*See Appendix B*).

(10) It is not to be excepted that Famine labour can work at these rates, and the work done by such labour should be kept distinct, and be allowed for accordingly; for example, in the last Famine earthwork is stated to have cost at the rate of about Rs. 20 per 1,000 cubic feet.

(11) As regards the materials for mortar and concrete. Mr. de Closets has made experiments with different proportions of lime, sand and surki, from which it would appear that mortar composed of 1 lime and 2 sand give the best results; and for concrete, mortar composed of 1 lime, 1 surki, mixed with 5 parts of red sand-stone broken up, gave the best results. In all such cases the best way is to make different samples on the spot and test the results, as conditions and materials often vary.

(12) It may be helpful to note here the usual proportions and method of treatment of concrete, and I cannot do better than quote from the specification on the Bhatgarh Dam.

(*a*) *Concrete.*—The concrete to consist of broken stone and clean gravel or shingle intimately intermixed with mortar of hydraulic lime after having been well wetted. The materials to be of all sizes up to what can be conveniently turned over and rammed, generally

3 inches maximum for metal and gravel, and ½-inch minimum for gravel. The proportions should be chosen so that all interstices are filled up completely, and the mortar just creams up on being rammed for 3 hours with rammers, as heavy as can be continuously used by labourers, varying from 9 to 20 lbs.

(*b*) The mortar will consist of two parts of sand, and one of slaked lime; and the usual proportions of the concrete will be :—

4 of metal 4 of gravel	3 of mortar	2 of sand. 1 of lime.

(*c*) The concrete is to be laid in courses, an average of 10 inches in thickness on alternate days.

(*d*) Heavy stones and boulders to be inserted in the concrete as it is being laid, with their thick end downwards, and to project beyond the upper surface of the layer so as to bond that layer with the next above, and also to add to the weight. They should generally form a third part of the whole, and should be well wetted before being laid. They should be placed so as to allow free ramming between them.

(*e*) The concrete will generally be layed in two layers, the first to be rammed for at least twenty minutes, and the second up to three hours.

(*f*) All masonry and concrete is to be watered constantly from the moment that the mortar in it sets sufficiently to allow of water being thrown over it.

(13) As regards the depth of core-wall—I consider if it is taken 10 feet below the original ground line, it is enough; if sound hard ground is met with at a less depth, then the concrete might be put, say, 4 feet deep.

The foundations were all dug before we came; where the ground is very hard they need not have been quite so deep, but it is a fault on the right side. The wall at each end should be stepped back into the original ground.

I would also suggest, if it is not possible to get the work completed before the rains, that it will be better not to carry the core-wall above the nullah bed, and even then to protect the down stream side with a good supply of rubble let into the bed to prevent any scour. The rubble could all be used afterwards in building up the wall.

(14) In the bed of the river, or wherever there is coarse sand, this should be removed for about 20 feet on each side, and good earth be rammed in its place, on each side of the wall.

(15) The whole trench to be filled in the full width, and well rammed in layers of 9 inches.

If the foundation has been excavated wider than required, it will be better even then to ram in the full width excavated, for at least 1½ feet thick. The portion above this to be made the required width, and some arrangement be made with planks, or by dry stone on each side, to prevent it spreading while being rammed. Heavy stones may be inserted in the concrete to project beyond the upper surface of the layer, so as to bond the layer with the next above it, and to add to the weight; they should be placed so as to allow free ramming between them. Above ground line uncoursed rubble masonry to be used with as large stones as possible.

The faces to be left rough, not to be pointed.

(16) When water occurs in the foundation the trench should be sub-divided by bunds of same sort across it into smaller compartments, out of which the water can be baled, or kept down by hand or pump, until the concrete has been rammed in—beginning at the point where there is least water and working towards the deepest place. To attempt to go down to an impermeable strata or rock appears here to be hopeless and unnecessary. The greatest depth of water will be only 17 feet; and 10 feet, as suggested for the depth of core-wall, if well backed with earth, rammed and brought up equally on each side, ought to be sufficient.

(17) If any leakage occurs hereafter in the river bed the toe of the outer slope can be protected with gravel and broken stone, to prevent any slip of earth, and the water can be used either by lift lower down, or for cultivation in the river bed.

(18) There are now the following number of persons employed here, about 2,000 altogether, of which the following are said to be on Famine Relief:—men, 500; women, 300; and children 500. It is advisable to have a Brahman employed to look after the conservation and distribution of the drinking water.

(19) Medical arrangements, I understand, are being made. This is advisable, and simple rules will no doubt be issued for guidance, in case of any sickness breaking out.

(20) It is advisable the Engineer Officer should have some hold over the Contractors. The usual rule is to withhold 10 per cent. of all bills, up to a certain sum, for the due performance of their contract until the completion of the work. Unless some proviso of this sort is enforced, it may be difficult to keep them up to the mark, or to prevent trouble afterwards.

(21) It will be advisable also to have a clear specification; or better still a sample of the masonry expected of the Contractors, in order to prevent any misunderstanding or discussion afterwards.

Note by the Consulting Engineer on the Jowai River Project.

On the 23rd February 1905 we reached Erinpura Road on the R.-M. Railway, and in the afternoon inspected the Jowai river. Mr. de Closets, the State Engineer, Assistant Engineer Battu Lall, and Overseer Jai Lall accompanied me.

We carefully examined the river near the proposed site for a Storage Reservoir, about half a mile above the Railway Girder Bridge, which consists of ten openings of 60 ft. each.

There is a very good site for a masonry dam, where good hard trap and syenitic granite is found across almost the whole bed of the river. The valley is contracted here, and the dam would consist largely of natural rock, which will save expense, and over which any overflow might pass without fear of harm. The flanks are protected by hills of solid rock.

At the north end of the proposed dam are two small gaps, which would have to be closed, and further north is a saddle in the range of hills, at a height of about 67 ft. above the bed of the river.

2. The following Note by Mr. de Closets will explain what was proposed :—

"This scheme is to dam the River Jowai, above the railway line, near Erinpura Road, utilising the whole or portion of the floods of the upper reach of the Jowai River (some 390 square miles) and turning it into the stream passing to the north and leading to a site near Baklia village, where by the natural formation of hillocks an amphitheatre for a large reservoir is formed.

"The damming of the Erinpura stream (the Jowai) at the place mentioned is proposed at a site where the stream runs deep among hills, and will necessitate a masonry dam, maximum height some 60 or 70 feet, which will be founded on rock; will be some 1,000 feet long, and which will form a Reservoir about 800 millions cubic feet in capacity, the upper 10 feet of which or 300 millions cubic feet can be utilised in direct cultivation, while the surplus can be partly turned by a wide feeder channel 15 chains in length, cut in a narrow gorge on the right flank into a nullah which crosses the Rajputana-Malwa Railway by a culvert of six 20-ft. arches. Some three chains below this bridge a small masonry dam across this nullah will divert the floods into a similar wide channel, and into the stream going to Baklia, which channel will be about 3 miles long.

"The catchment basin of the Baklia stream is 53 square miles only.

"Taking 10 per cent. as the run-off from this, and 20 inches as the average annual rainfall, the available storage will be 246·26 millions cubic feet."

The 390 square miles of catchment basin of the Jowai proposed to be intercepted and turned in the catchment of the Baklia stream is composed of hills and rocky ground, and the available for storage may be assumed at 20 per cent. of 25 inches rainfall, which would be 4,530·25 millions c. ft. Of this quantity, all that caused by small freshes, and a portion of the heavy ones aggregating some 3,000 millions c.ft., may be secured, and 200 millions c. ft. turned into the Baklia stream after 800 milions is utilized in filling the Erinpura Reservoir.

The Baklia Reservoir will be about 3,000 millions cubic feet in capacity, 8 square miles in area, and 40 to 45 feet in depth at bund. Only some 4,000 feet of bund will have to be raised to dam the valley near the village of Baklia, where the hills come close to each other.

A long saddle of hillocks stretches on the left flank, where an adequate byewash can be formed.

There are some lands at present above the site of the Baklia village, and which are cultivated by well Irrigation, this may represent some 600 or 800 acres. Some land in the bed of the Erinpura stream is planted with melons.

The cost of the scheme might be roughly 5 lakhs rupees for both Reservoirs, including canals, and would represent 7,000 c.ft. storage per rupee.

An alternative scheme which would do away with the Reservoir above the Railway would be a dam across the Jowai below the Railway, to turn only a portion of the freshes into the Reservoir at Baklia. Levels for this are being taken, as it is very much lower than the site above mentioned.

The Jowai River is a perennial stream, and besides filling the Baklia Reservoir during freshes may be expected to also replenish its supply for some time after the rains.

Mr. Home, in reply to the Consulting Engineer, Protective Irrigation Works, mentions, I think, this Project, thus:—

"Godhan tank will be situated in a depression adjacent to the Jowai River, and will be fed by a cut from this river, which will follow an overflow channel.

"This tank will cover a large area about 10 square miles, and will be shallow, the maximum depth of bund being 20 feet.

"The estimated cost is Rs. 1,50,000 without canals, and the capacity 1,200 millions c.ft., or 8,000 c.ft of storage space per rupee of cost.

"The catchment area of the Jowai River is not actually known as maps are not available, but it cannot be less than 400 square miles, situate mostly in the Aravalli hills.

"The river that will supply all the above tanks is in the Aravalli hills, and flows over generally hard ground in the district of Godwar. The rainfall in this district varies from about 12 to 18 inches in the plains in ordinary years, in the hills it is no doubt more."

In a Note supplementary to the above, he says, "I have been informed by the Durbar that the only inundations from the Luni that are of

any importance occur not in Mallani, but in Sanchore, and that they are caused not by the Luni river proper, but by the Jowai and its tributaries. If this is so, there would seem to be little objection to damming up all, or most of the rivers north of the Jowai, and as to the latter it would be, I think, advisable for an officer to visit Sanchore and study the question of these inundations (which are said to occur in 5 years), and see whether they could not be replaced by well cultivation. Pending this enquiry, I think that the damming of the Jowai or its tributaries on a large scale should not be undertaken."

In reply to this, the Mehekma Khas states:—"In Sanchore the inundations are reported to be due not so much to the Jowai or Erinpura streams, but to the overflow of the Luni. The first two streams cannot inundate the total area, nor can the water supplied by them to the Luni materially contribute to its inundations. The "Jugril" can only be obtained by the Luni alone. This circumstance, as also the fact that the Nair population which is solely dependant on its inundation for the exuberant crop of grass and fodder which is to last for a number of years, led the Hakim to argue that the Luni has a tangible influence of importance on inundation, and any scheme for bunding it up will prove injurious to the Nair class specially."

When it is considered that the catchment basin of the Jowai is about 3,000 square miles, and only 400 square miles of its upper reach is to be utilised in the Project set forth, or less than one-seventh its whole catchment, and further, that the River Luni has from below Jaswant Sagar to Sanchore, where the two rivers would seem to meet, and where the inundations take place, not less than 12,000 square miles of drainage area besides the percentage of water that would be drawn by the Project, would not in the least affect the inundations caused in Sanchore by the two rivers combined, the total drainage area which is 15,000 square miles, or 37 times more than the area proposed to be utilised.

The Project is one that would seem most profitable, and Mr. Home, in his Administration Report for 1901-1902, states also: "One Project which is regarded as a particularly promising one, the construction of a tank or series of tanks fed by the Jowai river, is at present under survey."

3. It will be seen the proposals are briefly:—

(1) To put a dam on the River Jowai to hold about 800 m.c.ft., the upper 10 ft. of which can be utilised in direct cultivation.

(2) The surplus to be partly turned by a wide feeder channel cut in a narrow gorge on the right flank into a nullah, which crosses the R.-M. Ry. under 6 arches of 20 ft. span each.

(3) To make a small masonry dam across this nullah, a short distance below this bridge, where a good site exists with

rock in the bed and sides, and to divert the floods by a cut into a nullah, which leads to Baklia.

(4) To form a Storage Reservoir at Baklia for Irrigation.

4. In order to utilise the water which would be stored in the Jowai Reservoir, the suggestion was made by the Consulting Engineer, before he had seen the place, to pass the water down the river for some distance until it reached a point where rock crops out, and to take a cut from the river away on the right bank; but on inspection it was seen that the banks are too high here, the expense would be very great, and the quantity of water which would be lost in the sandy bed of the river make anything of this sort not advisable.

The land on the left bank below the railway bridge belongs to the Sirohi State.

5. The drainage area at the site of the proposed Reservoir on the River Jowai is about 390 sq. miles. Owing to the rocky nature of the catchment the run-off would probably be at least one-third of the rainfall; taking this at 21 inches in ordinary years it would give about 6,240 millions c.ft. of water available for storage, which now all goes to waste.*

Besides this, the river is said to flow for some weeks after the rains in ordinary years.

6. The surveys have not been made yet, so it is not possible at present to say what height of bund will be advisable; but the Project is undoubtedly a good one, and should be prepared without delay.

7. There are, however, certain points about the above proposals which do not commend themselves to me, and which will be alluded to further on.

8. The question of the storage of the water for instance. It is true there are ranges of hills near Baklia, which at first sight of the map seem suitable places for storing water—a small range of rocky hills near Baklia itself, and another about a mile higher up, both these places were suggested. At both places, however, there are many wells, and any bunds here would submerge a large area of cultivated well land. This would be a certain loss to the Durbar.

At both places there would apparently be some difficulty about getting a suitable escape; and at Baklia probably a great part of the village would have to be removed. I do not think "the long saddle of hillocks on the left flank" alluded to as a site for the escape for the lower site would stand any overflow as it appears to be all sandy soil. Owing to the hills closing in, especially at Baklia, the Storage basin would be somewhat contracted.

For these reasons I do not approve of making a Storage Reservoir at either of these two places.

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* $\frac{1}{3}$ of 21 inches × $2\frac{1}{3}$ m.c.ft. from one inch on one sq. mile × 390 sq. miles = 6,240 m.c.ft.

9. After a careful inspection of the ground between the proposed dam on the River Jowai and the village of Baklia, the conclusions I have come to are:—

(1) To make a large main Storage Reservoir on the River Jowai at the site proposed, 100 feet high or more, if necessary.

The height will depend upon the quantity of water available in average years, and the capacity of the reservoir at different contours, approximately it should be high enough to impound at least the rainfall of an average year, say about 6,500 m.c.ft.

There need be no fear regarding the height of the dam if it is founded on rock everywhere and is properly built.

(2) The site is an excellent one for a large Storage Reservoir. The hills close in at the site, with a good spreading basin above. There is a good catchment area nearly all in the hills, and much of it rock. There are good foundations in rock. The material for the dam is on the spot, and is good and plentiful. There is no fear of any silting up.

There will apparently be no loss by submersion of valuable land or wells. There will be no difficulty about the overflow, which will be over hard rock. There is a good command of the country, and any amount of good first-class soil below for irrigation, for the whole country slopes away to the north-west for miles.

(3) It will be possible to put the outlet sluice in one of the gaps at the north end of the dam, and to take the duct from it, outside the base of the hill at the north end, and between it and the railway line.

This will enable water to be drawn off for irrigation at a much lower level without the trouble and expense of cutting down the saddle on the right flank alluded to above. To cut this down to any depth would be a heavy item, as it would be in solid rock nearly the whole way.

(4) If a high masonry dam is built these gaps and the saddle would be filled up with masonry, and form part of the escape.

(5) Water could be let out as required for irrigation, or to replenish any storage basins which may be constructed hereafter on the country below. The advantage of having the water under perfect control, instead of allowing the surplus to pass away (after storing 800 m.c.ft.) in flood is evident.

(6) To put a small masonry dam across the north (6 × 20') nullah as proposed, to divert the reservoir water into the proposed cut on the right bank.

(7) This cut could be used for irrigation, or as a supply cut to the Baklia nullah, to help fill or replenish any storage basins hereafter, if it is found after the construction of the main dam on the Jowai that there is water still to spare.

(8) Not a drop of water should be allowed to go to waste in a country like Rajputana.

(9) Where this cut comes out on to the country a distance, it is said, of about 6,000 feet, lay out Irrigation Canals.

The left Canal would follow the water-shed between the Jowai river and the Baklia nullah, passing near Ondri and Poman.

The right Canal would follow the general contour of the country, crossing the Baklia nullah at some convenient place, either by a bund or aqueduct, or level crossing, and working round in a northerly direction towards Rajra and Khidoni, so as to avoid the high rocky ground which appears on this side.

(10) Both these Canals would command a large area of the best land in the Marwar State. Most of it is entirely dependent on rainfall, and is now lying dry and barren. Both canals would débouché on the plain below Baklia, and the area for Irrigation is unlimited.

(11) These Canals would pass above all the area now cultivated near Khidoni and Baklia, and would injure neither wells nor land, but would command the whole area. If any of the existing wells failed it would feed them, and would, no doubt, help to raise the water level, which is now 70 to 80 feet below the surface, and enable wells to be made where now there is no inducement to make them.

(12) If extra storage tanks are ever required two sites suggest themselves on the Baklia Nullah, near Ondri—one above the Ajmer-Ahmedabad Road, the other below it, where a bund might be put stretching from small rocky hills near Ondri across to the high ground north, where the rocky ground would afford a safe escape.

Another good site seemed possible on a branch of the Baklia nullah on the north, stretching from this high rocky ground across a natural depression on to high ground in the direction of the village of Rajra.

Surveys will have to be made to determine the best line to take, and the height of bund and capacity of reservoir, which will depend upon the quantity of water available.

These are points which need not, I think, be considered at present, because if a large storage reservoir is made on the River Jowai extra storage reservoirs may not be necessary.

(13) The Project such as I suggest would insure the whole tract below it against Famine. It is unnecessary, perhaps, to allude to the advantage of having large storage reservoirs in preference to smaller ones in a country like Rajputana.

(14) The irrigated tract being near the railway there is every facility for disposing readily of any surplus produce, which would follow from increased cultivation.

10. I suggest Plans and Estimates for this grand project should be prepared without delay. There is the opportunity here of making a magnificent Storage Reservoir; of storing some 6,000 millions c.ft. of water which annually goes to waste, and of carrying out a work which would be of great benefit to the Durbar, and to the country.

I strongly recommend the Project for the consideration of the Durbar.

11. About 7 miles beyond Baklia, in a northerly direction, is a village named Takatgarh, where I am told is an earthen bund, now useless Mr. Home in his note on Irrigation alludes to this as one of the Projects ready to be taken up, as follows:—

(1) "Takatgarh is at present a small tank, the bund of which it is proposed to lengthen. The catchment area is about 70 sq. miles. The contents of the tank will be 103 millions c. ft. The Estimate is Rs. 38,000.

(2) It is said that the bund was originally made without professional help, that the escape was not sufficient, and that the top was not properly level, and that from these causes it was breached; also that there is now a quantity of earthwork, roughly estimated at about Rs. 10,000, lying useless, and that water is greatly needed in this part.

(3) I have not seen the work, but the Hakim of the district also suggested the advantage of the tank being repaired.

If the above facts are correct, it certainly seems a pity, that so much money should be lying unprofitable.

(4) It is of first importance to take advantage of such places, where a large amount of earthwork is ready to hand, and to complete such works, or the money which has been already spent might almost as well have been thrown away. This work is strongly commended to the consideration of the Durbar.

(5) This, and any other tanks in this direction could all be supplied from the proposed Reservoir on the Jowai, or from the Baklia nullah.

12. Looking at Irrigation generally, a point deserving of consideration is whether it may not be possible to bund up some of the streams over which the railway line passes, instead of bridging them.

This is not a procedure which could be attempted in ordinary cases, but the rainfall in these parts is so small, and the country so open that there is not the same danger from floods, which might perhaps be passed off at either end on higher ground.

If so, the expense of a bridge might be saved, and a supply of water would be stored, which either by percolation or irrigation lower down would benefit the country.

This is not a new idea, for it has been done at Salawas, about 12 miles from Jodhpur, on the line to the Marwar Junction ; and I understand from Mr. Todd, the present Manager of the Jodhpur-Bikaner Railway, it might, he thinks, be adopted elsewhere.

13. Another idea is, whether it might not be possible to extend the influence of Inundation from the Luni or other rivers. For instance, it is known that land in the neighbourhood of Sanchore is greatly benefitted by the overflow of the floods of the Luni.

If this area is marked out it would be seen that it extends up to a certain point. It would not do, of course, to lessen this area in any way, but by making a bund above this point it might, perhaps, be possible to inundate other areas on somewhat higher levels, and allow the surplus to pass on and take its usual course, and so get a larger area benefitted by inundation in one or more places, and make better use of the large quantity of water which now goes to the sea.

Whether this is possible or not I cannot say, as I have not seen the place, and have no data to go upon ; but knowing the benefits of Inundation, and believing that a good deal of water goes to waste, it naturally suggests itself as deserving of consideration.

The Resident, Western States, Rajputana (Col. Jennings, C.I.E., R.E.), writes, "I have asked for surveys to be made on the Luni River in the neighbourhood of Gura, above the Gulf of Kutch. I fully believe in your suggestion."

14. Before closing this report I think it advisable to point out the necessity of getting two or three extra Surveyors to carry out the surveys suggested, as a temporary measure at all events. There is a good deal of work to be done in out-of-the-way places, more than the present staff will be able to do in a reasonable time ; and if the Durbar wish to take up Irrigation properly, the first step is to get the surveys carried out to enable plans and estimates to be prepared. Every year's delay means so much water lost to the State.

JAIPUR,
March 1905.

S. S. JACOB, COLONEL,
Consulting Engineer for Irrigation in Rajputana.

APPENDIX A.

Estimate of probable cost of completion of Bankli Bund.

Description of Works.	Quantity.	Rate.	Per	Amount.	Total.
EARTHWORK.		Rs. A.		Rs.	Rs.
Chainage 34 to 47·50 lift to 40 ft. ...	4,400,000	6 0	1,000 c.ft.	26,400	
„ 47·50 to 121 „ 25 „ ...	8,000,000	4 8	„	36,000	
„ 6 to 150 dressing and filling old work	2,000,000	4 0	„	8,000	
PITCHING.					
With kunker to level 31·00, 6″ thick chainage, 15 to 150	s. ft. 730,000	2 8	100 s. ft.	18,250	
Total for Bund ...	.....	...	...	...	88,650
CORE-WALL.					
Coursed Rubble in Surki Mortar...	350,000	20 0	100 c. ft.	70,000	
Concrete foundation in do. ...	25,000	16 0	...	4,000	
Cost of two pumps...	Two	500 0	each	1,000	
For bailing, pumping, etc. ...	.....	...	...	1,000	
Total for Core-wall ...	.....	...	...	...	76,000
SLUICES.					
Coursed Rubble Masonry	c. ft. 30,000	20 0	100 c. ft.	6,000	
Concrete	10,000	13 0	„	1,300	
Arching	6,000	30 0	„	1,800	
Slab-flooring	2,500	15 0	„	375	
Screw-geared shutters $2 \times 2\frac{1}{2}'$ diameter	Two	300 0	each	600	
Puddling	lump	sum	...	200	
Total for Sluices ...	.....	...	...	...	10,275
Total ...	.....	...	...	...	1,74,925
Add Contingencies @ 5 per cent....	.....	...	...	...	8,700
GRAND TOTAL ...	.....	...	...	...	1,83,625

JODHPUR,

22nd November 1904.

(Sd.) LOUIS DE CLOSETS,

State Engineer.

APPENDIX B.

Revised Estimate of probable cost of completion of Bankli Bund.

Description of Works.	Quantity.	Rate.	Per	Amount.	Total.
EARTHWORK.		Rs. A.		Rs.	Rs.
Sandy Soil.					
Chainage 34 to 47·50 lift to 40 ft. ...	4,400,000	6 0	100 c. ft.	26,400	
„ 47·50 to 121·00 „ 25 „ ...	7,400,000	4 8	„	33,300	
„ 6 to 150, dressing and filling old work	2,000,000	4 0	„	8,000	
Pitching.					
Kunker to level 31·00, 6″ thick chainage, 24 to 80 and 92 to 121 ...	638,700	2 8	100 s. ft.	15,968	
Total for Bund ...	... ..	...	...	...	83,668
Core-Wall.					
Random Rubble in Surki Mortar, level 95 to 137, chainage 34 to 47	273,000	17 0	100 c. ft.	46,410	
Concrete foundation in Surki Mortar, level 190 to 95, chainage 37 to 47	65,000	14 0	„	9,100	
Cost of two pumps...	Two	500 0	each	1,000	
Coping to Core-wall	1,300	30 0	100	390	
Cost of pumping, &c.	lump	sum	...	1,000	
Total for Core-wall ...	.....	...	...	...	57,900
Sluices.					
Concrete in ordinary mortar ...	7,533	12 0	100	903	
Flooring with slabs do. ...	1,267	12 0	„	152	
Masonry in ordinary do. ...	6,252.	15 0	„	938	
Arching do. do. ...	1,614	30 0	„	484	
Slab roofing do. do. on edge	737	30 0	„	221	
Ashlar	856	30 0	„	500	
Puddling	lump	sum	...	500	
Screw geared shutters	Eight	150 0	each	1,200	
Total for Sluices ..	... ..	..	..	...	4,655
Total ...	. ...	...	...	...	1,46,223
Add Contingencies @ 5 per cent....	.....	...	...	..	7,311
Grand Total ...	.....	...	...	...	1,53,534

Jodhpur,

2nd March 1905.

(Sd.) LOUIS de CLOSETS,

State Engineer.